Air Force Materiel Command

Developing, Fielding, and Sustaining America's Aerospace Force

Air Force Laser Coatings Removal Program

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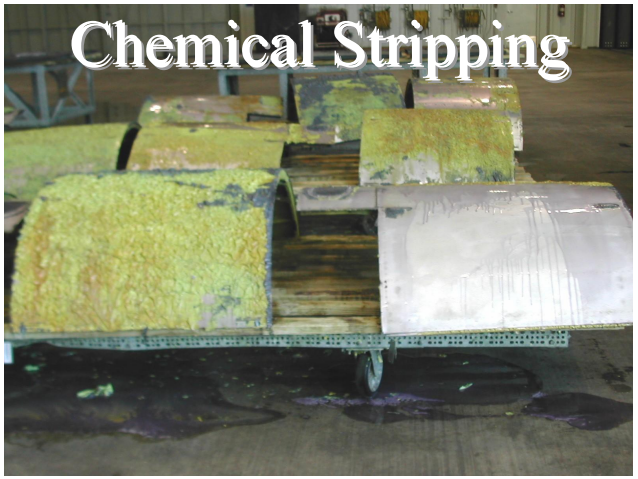
Integrity - Service - Excellence

Overview

- Problem Statement – Current Coating Removal Operations
- Air Force Laser Program
  - Current Air Force (AF) Laser Coating Removal Programs
    - Portable Handheld Laser Coatings Removal System (PLCRS)
    - Specialty Coatings Laser Removal System (SCLRS)
    - Glovebox
    - Robotic Laser Coatings Removal System (RLCRS)
    - Advanced Robotic Laser Coatings Removal System (ARLCRS)
- Summary

Problem Statement

Current Coating Removal Operations At ALCs



Supplemental stripping is an expensive, time-consuming process that creates hazardous waste & emissions

Air Force Laser Coating Removal Program

Program Goal:

Establish and expand the use of laser technology as a viable alternative technology for coating removal in remanufacturing operations

Benefits

- ✓ Reduce Flow Time
- ✓ Cost Effective
- ✓ Safety Compliant
- ✓ No Damage to Substrate
- ✓ Selective Stripping
- ✓ Increase Facility Capacity
- ✓ Environmentally Friendly

Approach

Phase I

Handheld laser coating removal applications

98% Complete

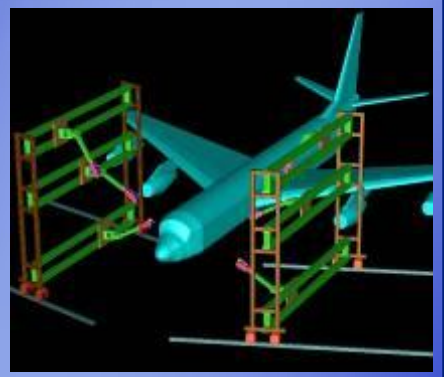
Phase II

Large area, off-aircraft laser coating removal applications

60% Complete

Phase III

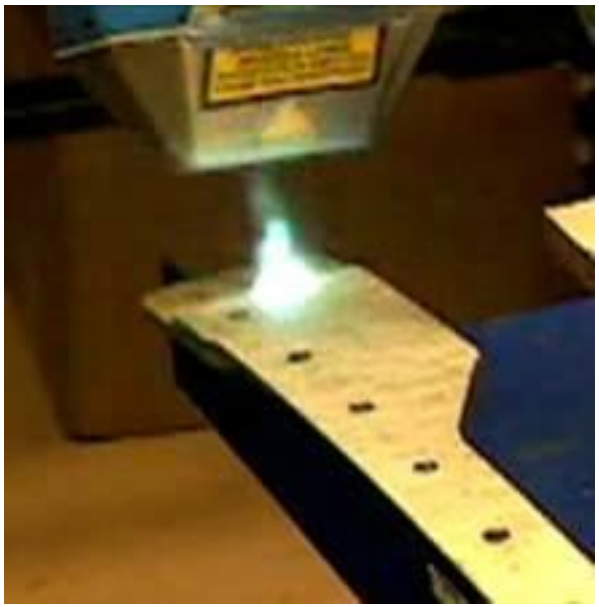
Automated full aircraft laser coating removal applications



Design Phase In-Progress

Phase I Programs

Handheld Laser Coatings Removal Systems

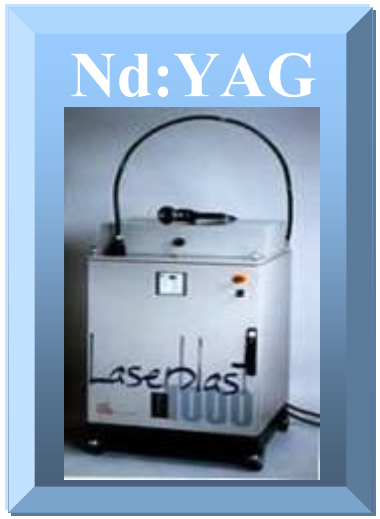


- Objective:
  - Evaluate ability of hand-held laser systems to supplement existing small-area depainting processes on components and aircraft at depot and field levels
    - Task 1 – Standard Coatings
    - Task 2 – Specialty Coatings
- Benefits/Impacts:
  - Increase production rate
  - Replace Methylene Chloride, MEK, and PMB uses
    - Reduce hazardous waste generation
    - Reduce handling and storage
    - Reduce worker exposure to known carcinogenic materials

Phase I Program

Laser Systems

- Handheld Laser systems tested:
  - 40 Watt Nd:YAG laser, 1064 nm wavelength
  - 120 Watt Q switched Nd:YAG laser, 1064 nm wavelength
  - 500 Watt Q switched Nd:YAG laser, 1064 nm wavelength
  - 250 watt CO_2 laser, 10,600 nm wavelength
  - 250 watt Diode laser, 808 or 940 nm wavelength



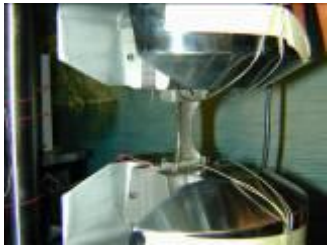
Phase I Program
Task 1 - Testing Protocol

Test Specimens

- Substrates:
  - 4130 Steel
  - 2024 and 7075 Aluminum
  - Graphite epoxy
  - Fiberglass epoxy
  - Metallic honeycomb
  - Kevlar
- Coatings:
  - Primer
    - MIL-P-23377G
    - MIL-P-53030
    - PR1432GP
  - Topcoat
    - MIL-C-46168, Type IV
    - MIL-C-64159, Type I (CARC)
    - MIL-PRF-85285, Type I

Mechanical Testing

- Removal Rate
- Visual Damage
- Substrate Temperature
- Clad Penetration
- Surface Profile
- Paint Adhesion
- Hardness
- Fatigue
- Tensile Strength
- 4 Point Flexure (composite)



Phase I Program
Task 1 - Testing Results

Removal Rate

- Adequate average removal rate for small area/nitpicking operations (≈14 in^2/min)

Visual Damage Assessment

- No visual indication of surface damage

Substrate Temperature

- **Results:** Measurements confirmed temperature spikes are not high enough to cause damage
  - Temperature rise
    - <200° F for 120 watt Nd:YAG
    - <150° F for 40 watt Nd:YAG

Test results indicate use of laser does not significantly affect common substrate materials

Full Set of mechanical test results compiled in ESTCP Final Report (August 05) - www.estcp.org

Phase I Program

Task 2 - Specialty Coatings

- Ability of hand-held laser systems to remove specialty coatings was also evaluated
  - Powder Coating
  - Radar Absorbing Material (RAM)
  - Low Observable (LO) Materials
  - Conductive Coatings
  - Sealants
- 500 Watt Q switched Nd:YAG laser, used for stripping trials
  - Lower powered lasers were not able to efficiently remove the thick specialty coatings
- Preliminary results show the Nd:YAG laser tested:
  - Can remove thinner coatings (powder coat and spray LO) and fastener filler quickly and efficiently without overheating the substrate
  - Can remove small areas of sealant efficiently but may not be fast enough to treat large areas
  - Can remove spray RAM and gap filler but the current configuration is not conducive to doing so efficiently
- Final results of mechanical testing are expected to be complete in Nov 06

Phase I Status

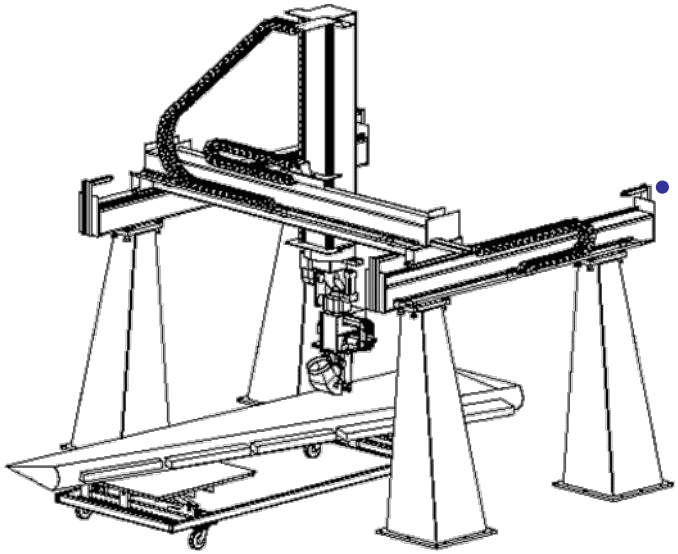
ACTIVITY	STATUS	RESULT
Task 1 - Portable Hand Held Laser Coating Removal System		
Materials Compatibility	100 % Complete	
Environmental Evaluation	100 % Complete	
Safety Evaluation	100 % Complete	
Occupational Health Evaluation	100 % Complete	
Task 2 - Specialty Coating Laser Removal System		
Panel Stripping	100 % Complete	
Mechanical Testing	95 % Complete	In Work

Transition of Handheld Lasers in progress

- Technical procedures drafted for inclusion in T.O. 1-1-8
- Handheld laser systems provided to 3 depots for implementation
  - Ogden Air Logistics Center (OO-ALC),
  - Oklahoma City Air Logistics Center (OC-ALC)
  - Warner Robins Air Logistics Center (WR-ALC)

Phase II Program

Robotic Laser Coating Removal System (RLCRS)



- Objective:
  - Dem/val robotic laser coating removal system to replace current chemical/mechanical coating removal methods used on large off-equipment components
- Benefits/Impacts:
  - Reduce stripping time – increased production
  - Replace chemical strippers, MEK, PMB and wheat starch
  - Potential reductions at OC-ALC include:
    - 13,200 gallons paint stripper
    - 341,260 pounds of solid waste
    - 4003 pounds of VOCs
    - 1,815,000 gallons contaminated waste water

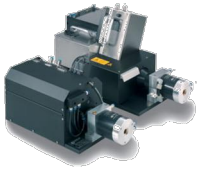
Phase II Program
RLCRS System

Robotic Laser System is comprised of several main components

Laser Source

Rofin Sinar CO2 laser
- 6 kW average power
- Highest beam quality of lasers investigated
- Low gas consumption
- Low maintenance requirements

Scanning Optics



Scanlab USA powerSCAN Optics
- COTS system
- Low beam loss (<2%)

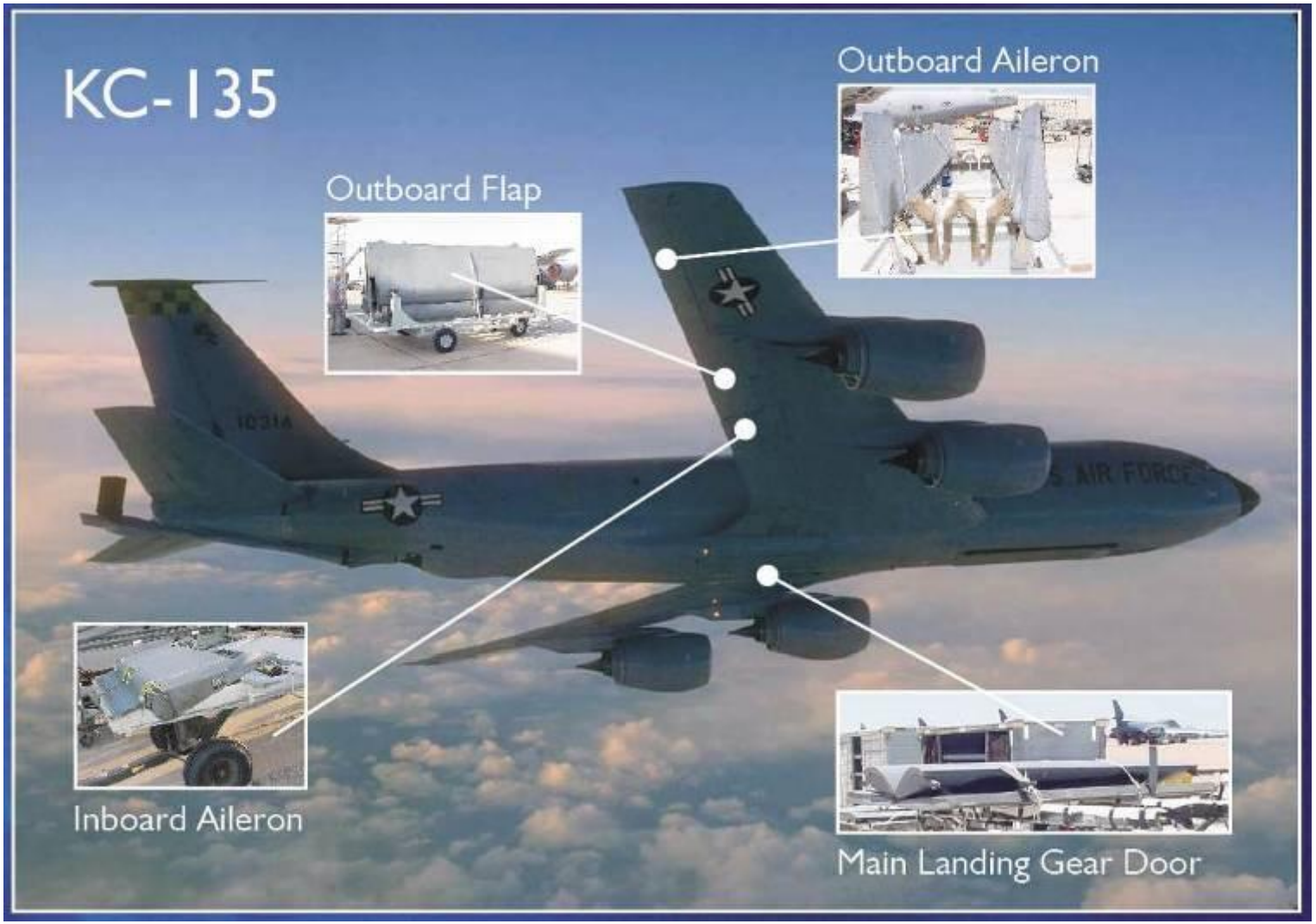
PaR Systems Gantry Robot
Operating Envelope: 116” x 116” x 60”
Existing system from SERDP funded program
Re-commissioned with modern control system
Commissioning completed 12/05

Contour Following

- Will allow consistent stripping regardless of part geometry
- Several types of contour following sensors available
- Currently evaluating IR and laser sensors
- Contour following control to be completed 3/06

Phase II Program
Parts To Be Processed By RLCRS

- Flaps
- Ailerons
- Rudder
- Leading Edge Panels
- Landing Gear Doors



Phase II Program
RLCRS Approach

Task III – System Transition and Demonstration

- Transition system to OC-ALC & train staff (Feb 07)
- Perform Demonstration (Aug 07)
- Compare performance versus baseline data (Sept 07)
- Final Cost Benefits Analysis and Final Report (Dec 07)

Task II – System Assembly and Debugging

- Assemble system (Complete)
- Perform debugging at *CTC* Demo Factory to prevent interference with production at OC-ALC (25% - Feb 07)
- Prepare Demonstration Plan (Complete)
- Perform facility preparations at OC-ALC (Ongoing)

Task I – System Design

- Evaluate and select system integration company **(Complete)**
- Evaluate and select system components **(Complete)**
- Develop design specifications & procure components **(Complete)**
- Perform Initial Cost Benefits Analysis and Performance Baseline **(Complete)**

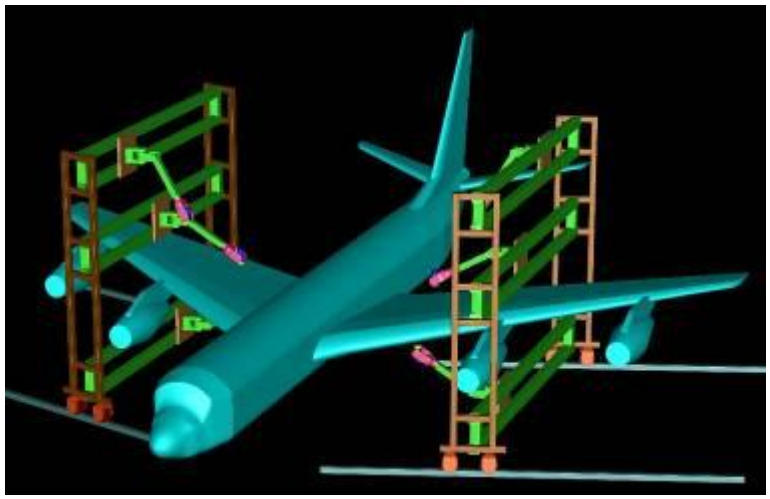
Phase II Status

ACTIVITY	STATUS
Upgrade of Gantry Control System	Complete – Movement of all 6 axis verified 12/05
System Design	Complete
Procurement of Major Components	Complete – All major components received and integrated
System Assembly / Debug	75% Complete
Materials Testing	10% Complete – Estimated completion in Jan 07
System Transition to OC-ALC	Estimated FY 07

Project On Schedule for Transition to OC-ALC in FY07

Phase III Program

Advanced Robotic Laser Coating Removal System (ARLCRS)



- Program Goal:
  - Test, evaluate, and implement laser and robotics technology for automated, full aircraft stripping in remanufacturing operations to:
    - Reduce cost, flow time, and environmental burden
    - Improve facility throughput and operator occupational safety
    - Reduce substrate damage and associated repairs
    - Enable selective coatings removal
- Program Evolution:
  - ARLCRS program leverages the PLCRS and RLCRS programs to offer a comprehensive solution

Phase III Program
ARLCRS Task I: Feasibility Analysis

- Conducted large aircraft stripping (KC-135) Feasibility Analysis
- Baseline current full aircraft depaint process
- Identify robotic alternatives
  - Established conceptual layout (75% confidence interval [CI])
  - Evaluated robotic conceptual layouts to develop full aircraft stripping
  - Identified and assessed laser systems
    - Selected fiber laser system
  - Gathered ancillary systems information
  - Procured selected laser

Phase III Program
Task II: Prototype Design

- Perform laser demonstration tests
  - Identify, procure, and test system subcomponents
  - Optimize and conduct laser stripping, testing and analysis
- Procure prototype robotic system
  - Refine design and install prototype in Johnstown, PA
    - In process of integrating applicable concepts for detailed design (95% CI) for full aircraft stripping
  - Obtain F-16 aircraft
- Initiate full-scale implementation planning
  - Identify full equipment needs and total costs (F-16)
  - Develop training materials and implementation plan
- Develop prototype test plan
- Plan prototype demonstration
  - Identify facility, material, and aircraft requirements and considerations
  - Develop depaint optimization plan and prototype parameters

Phase III Program
Task III: Prototype Demonstration

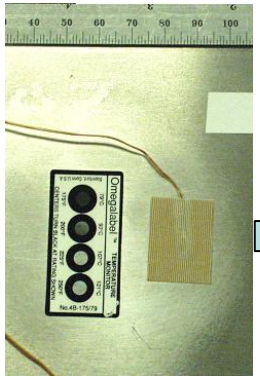
- Conduct demonstration testing (F-16)
  - Disassemble aircraft (as needed)
  - De-coat aircraft (repeat as needed per test requirements)
  - Characterize materials
  - Capture processing data
- Plan full scale-up
  - Determine location
  - Obtain funding/aircraft engineering approval
  - Finalize design and process

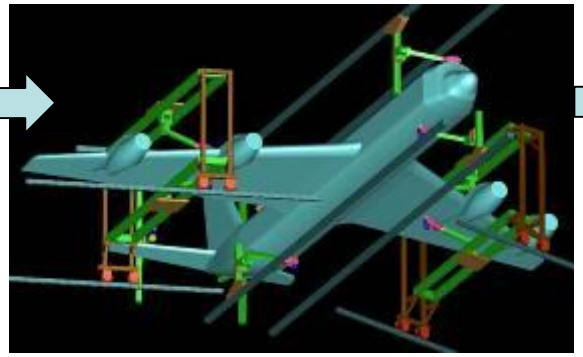
Phase III Program
Task IV: System Scale-Up

- Procure full-scale equipment
  - Procure robotic and laser system and associated ancillary equipment
  - Develop equipment acceptance test
  - Complete logistics plan for ALC
  - Coordinate and assist with subcomponent integration
- Install, integrate and debug full-scale system
- Demonstrate system

Phase III Status

ACTIVITY	STATUS
Task I – Feasibility Analysis	Complete – System shown to be feasible, preliminary design complete, laser system ordered
Task II – Prototype Design	10% Complete – Detailed system design begun
Task III – Prototype Demonstration	FY 08
Task IV – System Scale-Up	To Be Determined





Summary

- Laser technology is proven and available
- Results achieved during laboratory testing are positive
- Air Force Program results are being utilized by other organizations to develop their own laser capabilities
  - U.S. Air Force Depots (OC-ALC and OO-ALC)
  - U.S. Army (Ft. Rucker)
  - NASA
  - Coast Guard
  - OEMs (Boeing Aircraft, Raytheon Missiles)
- Based upon favorable results efforts are being made to evaluate laser technology for larger surface area applications
  - Combination of laser technology with robotics

Additional information available on the Air Force Laser Library
http://laser.ctcnet.net